LEVERAGING OPEN INNOVATION USING INTERMEDIARY NETWORKS

COREY BILLINGTON

Tel: +41 79 755 5923 Email: Corey.Billington@e3associates.com

RHODA DAVIDSON

Tel: +41 79 707 8555 Email: Rhoda.Davidson@e3associates.com

E3 ASSOCIATES

CHEMIN DE CRET-DE-PLAN

1095 LUTRY

SWITZERLAND

www.e3associates.ch

ACCEPTED FOR PRODUCTION & OPERATION MANAGEMENT JOURNAL

SPECIAL ISSUE

LEVERAGING OPEN INNOVATION USING INTERMEDIARY NETWORKS

ABSTRACT

Open innovation, fuelled by the rise of the Internet, has made it feasible and cheaper for firms to open themselves up to a wide range of external sources of innovative ideas. The explosive growth of intermediary networks, such as InnoCentive or Linked-in, enables the rapid pairing of firms seeking knowledge to address a wide range of business challenges (seekers) with other firms or individuals who already have relevant knowledge (solvers or knowledge brokers). These intermediary networks allow companies to source codified and un-codified knowledge from firms or individuals outside their traditional supplier networks using one-off transactional relationships. Although sourcing ideas in this way theoretically poses problems for knowledge search and transfer, we have found that companies can draw on processes and integration mechanisms developed by procurement and design engineering to develop effective organizational learning routines. These routines are strategically vital to source new ideas and create competitive advantage.

Keywords: open innovation, networks, procurement, supply chain management

1. INTRODUCTION

Over the last decade supplier networks have been recognized as a superior source of innovation (von Hippel, 1988; Powell Koput and Smith-Doerr, 1996; Dyer and Singh, 1998; Dyer and Nobeoka, 2000). Empirical research has shown these networks to be a locus of innovation where knowledge transfer takes place between manufacturers, suppliers, and users. It is argued that networks with a superior capacity for learning and knowledge transfer are able to "out-innovate" single firms or networks with less effective knowledge sharing routines (von Hippel, 1988). These supplier innovation networks are typically characterized by strong social network ties with a variety of institutionalized routines that facilitate knowledge flows among companies and their suppliers (Dyer and Nobeoka, 2000).

In recent years the conceptualization of innovation has broadened to include innovation with companies beyond the traditional supplier base. Companies are now looking at how they can use open innovation to bring in knowledge from distant sources to increase shareholder value. Open innovation involves the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand markets for external use of innovation, respectively (Chesborough, 2005). This paradigm assumes that companies can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to develop and enhance their business models. From an operations perspective open innovation is a form of procured service and similar to all procured services is subject to the make-or-buy decision (Cassiman and Veugelers, 2006).

Lately, the Internet and the growing prevalence of social networking have added a powerful twist to the open innovation concept by significantly reducing the cost of innovation and speeding up knowledge acquisition. The explosive growth of intermediary networks, such as

InnoCentive or Linked-in, enable the rapid pairing of firms seeking knowledge to address a wide range of functional or business process challenges (seekers) with other firms or individuals who can approach problems from many different angles. The core premise is that "somebody out there" may have already solved the seeker's problem before and they can be found, contacted quickly and efficiently via the Intranet. In essence, business problem solving changes from solving problems to finding answers.

These new ways of working are transforming managers' perspectives on how they look for new ideas and external knowledge exploration. However, the detailed operational know-how regarding how to conduct open innovation in specific situations and contexts, is not widely known. Using an open innovation approach requires firms to learn new organizational routines. Firstly, companies need to be able to look well beyond fixed relationships to more one-off transactional relationships with organizations and individuals with which there is rarely even a pre-existing relationship and who are not in their industry and with whom there is no expectation of a continuing relationship. Specifically companies must be able to routinely and effectively use the growing number of intermediary networks (also termed innovation markets (Chesborough, 2007)) that can connect them to brokers of knowledge who have answers. Secondly, companies need to develop routines to put the codified and un-codified knowledge that they find into practice in a repeatable manner. Although accomplishing both of these activities is fraught with knowledge search and transfer challenges, we have found that companies can draw on routines developed by procurement and design to create effective learning routines to deal with these new ways of working.

The goal of this paper is to describe the procurement, integration and operational routines that companies can use to bring in new ideas from organizations that are not included within

their conventional supplier networks. We show how companies can address the innovation dilemma of how to bring in external knowledge by harnessing the power of intermediary networks. We elaborate and contrast the different organizational routines needed to bring in codified and un-codified knowledge. Our conclusions are based on five years of exploratory qualitative case research and action research with 16 major multi-national companies from a wide range of industry sectors and 2 major NGOs. This research contributes to the theory of knowledge transfer and knowledge work integration by demonstrating that with appropriate procurement and design routines it is possible to transfer knowledge from wide-ranging non-local searches into an organization using weak social network ties.

2. OPEN INNOVATION AS A SOURCING OPPORTUNITY

Researchers have recognized that the locus of innovation in firms has been progressively changing over time. In the early 1960s and 1970s companies "invented" new products, services and business processes largely by using the capabilities of researchers located in an internal R&D or corporate department. Innovation was seen as the activity of lone entrepreneurs or small groups of corporate researchers assisted by consultants or university faculty.

By the 1990s companies in certain industries were actively tapping into the knowledge of their suppliers and their customers. It was recognized that networks of firms may be critical for competitive success and that companies learn by collaborating with other companies as well as by observing and importing their practices (Powell et al., 1996; Dyer and Singh, 1998). Inter-company learning became a key focus of researchers and networks with superior knowledge transfer mechanisms were argued to be more innovative than other networks (March and Simon, 1958; Levinson and Asahi, 1996; Kraatz, 1998; von Hippel, 1998; Dyer and Nobeoka, 2000).

For instance, empirical research in the biotechnology industry demonstrated that the locus of innovation was the network and not the individual firm and that firms which positioned themselves in "learning networks" are able to create a competitive advantage (Powell et al. 1996). As another example, an in-depth study in the automotive industry demonstrated that Toyota's ability to effectively create and manage network-level knowledge-sharing processes at least partially explained the relative productivity advantages enjoyed by Toyota and its suppliers (Dyer and Nobeoka, 2000). Toyota managed to solve knowledge-sharing dilemmas by creating a network of initially weak ties that evolved into a highly interconnected strong tie network with rules for participation and entry into the network.

As a result of increased company participation in learning networks, the locus of innovation extended to include a wide range of companies and individuals embedded in different types of networks. Internally-focused innovation models were replaced by a highly interactive process with lead users, suppliers and with a range of firms within the innovation system (von Hipple, 1988; Brown and Eisenhardt, 1995; Szulanski, 1996; Laursen and Salter, 2006). In these new models innovators come together in nested communities of practice, embedded in a dense network of interactions (Scott and Brown, 1999; Brown and Duguid, 2000; Laursen and Salter, 2006). The innovation process is one where people across firms work together in an iterative process of trial and error, termed whirlwind innovation, to bring about the commercialization of new ideas (Rosenberg, 1982; von Hippel, 1988; Tidd, Bessant and Pavitt, 2000; Terwiesch and Ulrich,2009). These networks are typified as tightly bound, with well-defended perimeters and strong social network ties that allow the diffusion and transfer of knowledge (Hansen, 1999; Dyer and Nobeoka, 2000; Tsai, 2002).

During the last decade the locus of innovation has moved once again to include a much broader network of firms and to view innovation as ever more highly distributed. Chesbrough's concept of open innovation has gained in popularity with companies (Chesbrough, 2003). At the centre of the open innovation model is how firms use ideas and knowledge from outside the firms' boundaries. Open innovation advocates that companies can and should use external ideas as well as internal ideas and that these ideas can be used to enhance internal R&D strategies (Chesborough, 2005). An over-quoted example of this open innovation model is Proctor & Gamble's (P&G) creation of the "Connect & Develop" strategy which involved senior management setting the ambitious target that 50% percent of new ideas should be sourced from outside the company and incorporated into new product development (Sakkab, 2002).

The Internet's effect of tremendously reducing the cost of connecting with others has fuelled open innovation and has made it feasible and cheaper for firms to open themselves up to a wide range of external sources of innovative ideas. For instance, in 2000 Goldcorp, one of the world's top gold producers had the problem that some of its mines were performing very poorly compared to other mines in northwestern Ontario, Canada. The CEO took the bold move to broadcast the entire geological data record of the company's Red Lake Mine (Tapscott, 2006). He offered $575,000 in prize money, with a top award of $105,000 to the person or company that would give Goldcorp an effective way to mine more gold. The broadcast of the challenged led to two Australian companies collaborating to come up with a three-dimensional depiction of the mine. Using this graphical data Goldcorp was able to lift the annual production of the mine from 53,000 ounces at a production cost of $360 an ounce in 1996 to 504,000 ounces at a production cost of $59 an ounce by 2001. An interesting facet of this example is that by using open innovation Goldcorp collaborated with two companies that were not established suppliers and

with whom they had no previous network relationships or social ties. Also the company worked in a way considered as unusual or dangerous by the industry.

New network structures are developing both formally and informally to facilitate the search and transfer of new ideas. We use the term "intermediary" to describe these networks. An intermediary network is defined as a formal or informal collection of people or companies that facilitates a productive working relationship between two previously unconnected parties, usually on a one-time basis. The Internet provides the facilitation mechanism to link a problem presented by a manager or organization (the seeker) with a myriad organizations or people worldwide who have the skills and time to consider the problem and share a solution if they already have one.

These emerging intermediary networks vary in terms of the degree of codification of the knowledge that can be tapped and in the degree of facilitation of the networks (Figure 1).

Insert Figure 1 about here

In terms of codification, knowledge can be defined as either tacit or explicit (Kogut and Zander, 1992). Un-codified knowledge consists of tacit knowledge embedded in individual experience and is regarded as difficult to communicate or transfer to others (Nonaka, 1994). Codified knowledge consists of explicit knowledge that is objective and relatively easily transmissible. The degree of knowledge codification has been found to be an important determinant of the speed by which major innovations are transferred within and among firms (Zander and Kogut, 1995).

One striking example of an intermediary site that deals primarily in codified knowledge is InnoCentive, launched in 2001 by Eli Lilly (Billington and Jager, 2008). Seekers place challenges on the InnoCentive platform and "Solvers" provide solutions that can be anonymously captured, codified and transmitted to the seeker. The companies or individuals who respond to the challenges are termed "solvers" in the sense that they have a solution to the posted problem which they are willing to document. The seekers, who are nearly always corporations or non-profit organizations, pay an annual fee of $100,000 to access the network and then offer a bounty to the solvers. InnoCentive also receives a percentage of this bounty paid. The fast-growing network of solvers was approaching 170,000 by mid-2010. Over time InnoCentive has expanded its service offering and domain coverage from the initial core offerings in life sciences, to include other domains such as mathematics and statistics, entrepreneurship, and engineering design.

Other intermediary sites provide ways to place seekers in contact with others who have the tacit knowledge required as input to solving their problems. These sites are primarily social networking sites, such as Linked-in or Facebook, or expert knowledge networks. Within these sites more formal intermediary networks have developed around topics and interest groups. For example, Facebook now has over 20 millions user groups. These knowledge sources may be able to offer unstructured tacit knowledge that can be leveraged and combined with other knowledge by the seeker. We term these sources "knowledge brokers".

In the procurement of services it is a routine consideration of who will manage the outsourced services; the buyer or the outsourced agent (Parker and Anderson, 2002; Amaral, Anderson and Parker, 2011). Similarly in our research we have found that documented codified

knowledge is used by the firm in their existing routines but that un-codified knowledge is used as input to the seekers' innovation process and forms departure points for creating new routines.

Intermediary networks also vary according to the levels of facilitation. Facilitated networks tend to deal primarily in codified knowledge, we term these networks seeker-solver networks (Table 1). One of the key roles of facilitation, apart from the linking of seekers and solvers, is the creation and maintenance of procedural and distributive fairness (Chan Kim and Mauborgne, 1993). For codified knowledge transfer this involves making sure that solvers are rewarded rather than exploited and in providing processes and routines that protect the IP of the solvers. For un-codified knowledge the role of facilitation is primarily to help seekers find knowledge brokers with appropriate tacit knowledge and to organize appropriate media for the transfer of this knowledge. For instance, Gerson Lehrman is an expert network with over 200,000 professionals ranging from scientists, doctors, academics, and former professionals from companies (Gerson Lehrman Group, 2010). Research managers from Gerson Lehrman assist seekers in finding experts through this network and facilitate contact with experts through phone calls, round tables, written reports, surveys, and visits.

Insert Table 1 about here

These facilitated intermediary networks are growing rapidly in size and also in the number of domains served. Table 1 provides examples of facilitated networks in the areas of R&D, science and technology, marketing, sales and predictions, general management and employment.

In essence, intermediary networks are novel procurement structures enabled by the Internet. Such networks are becoming useful because they are significantly less expensive than conventional mechanisms for developing and procuring innovative solutions. Empirical evidence from the pharmaceutical industry found that a seeker-solver network in the R&D domain can be more than 20 times less expensive than regular R&D paths (Rayner and Panetta, 2005; Lakhani et al., 2006). Investigators carefully studied 12 challenges and found that the gross value created was $10.3 million – a 2,600 percent return on investments that comprised $333,500 in prizes awarded to solvers and total internal costs of $60,000. While not all challenges are answered, the cost of unsuccessful challenges is significantly less than the cost of a failed internal R&D effort. However, for InnoCentive nearly 60% of challenges are resolved. Using these networks enables companies to access smaller companies, volunteers, retirees or low-paid hobbyists to resolve what once were seen as specialized technical issues. It has also been found that increasing the number of solver backgrounds in a challenge greatly increases the probability of finding a solution. For instance, an analysis conducted on InnoCentive challenges with six backgrounds versus three increased the chances of finding a solution by more than 30% (Lakhani et al., 2006). Empirical evidence from business process redesign has found that using external ideas from other industries enabled teams designing new processes to complete projects twice as quickly as they would have expected using conventional project techniques with increased new process effectiveness (Billington and Davidson, 2010).

Using these networks is highly relevant when firms procure services on a non-repeating basis and under conditions of high uncertainty and is particularly salient for complex innovation with unforeseeable uncertainty e.g. distributed product design (DPD) (Sommer and Loch, 2004; Terwiesch and Xu, 2008; Amaral et al, 2011).

By using these networks companies can rapidly extend the boundaries of innovation search and essentially put millions of brains to work (Figure 2). Companies are now able to outsource parts of central business processes to suppliers that are completely unknown at the time of the outsourcing. This provides a stark contrast to traditional practices that only consider innovation collaboration with long-standing partners (Figure 3). This is a growing phenomenon that is unlikely to go away.

Insert Figure 2 & 3 about here

---

3. CHALLENGES OF USING INTERMEDIARY NETWORKS FOR INNOVATION

Researchers of traditional supplier networks have highlighted a number of different challenges for effective knowledge transfer. These include the costs associated with finding and accessing different types of valuable knowledge within the network, how to motivate members to participate and openly share valuable knowledge while preventing undesirable spillovers to competitors, and how to prevent the free rider effect (Dyer and Nobeoka, 2000; p349).

Open innovation networks, and in particular the facilitated ones, have succeeded in at least partially overcoming some of these dilemmas. With the use of internet platforms transaction costs for linking seekers with potential knowledge sources (solvers and knowledge brokers) has plummeted. However, there are still significant costs of creating and maintaining internal routines and capabilities which are not insignificant and so require some minimum scale of use to amortize investment. Free rider issues occur when members of a network can enjoy the

benefits of the collective good created by that network without contributing to its establishment or maintenance. In open innovation, many of the facilitated intermediary networks resolve this issue by creating private exchange of knowledge between the seeker and the source of knowledge that is not accessible to other network members. Problems of source motivation are partially overcome in facilitated intermediary networks by offering monetary incentives to seekers. IP spillovers are limited through formal IP agreements between seekers and solvers.

However, the use of open innovation for knowledge search and transfer is still theoretically problematic (Table 2). Firstly, when companies attempt to find new technology or to adapt routines this typically takes place locally within the neighborhood of practices that have evolved within an organization (Nelson and Winter, 1982; Levitt and March, 1988). The Not Invented Here (NIH) syndrome is well documented and can prevent employees from even looking for sources of external ideas outside the boundaries of the firm (Katz and Allen, 1982). By indulging in local search, firms focus on similar technology and create incremental innovations. However, the ability to exploit external knowledge is a critical component of innovative performance (Cohen and Levinthal, 1990; 128). Empirical studies have shown that when search processes do not span both organizational and technological boundaries then this negatively impacts subsequent technological evolution and innovation performance (Rosenkopf and Nerkar, 2001; Katila and Ahija, 2002; Laursen and Salter, 2006). Researchers argue that too much internal introspection leads to the development of competency traps (Levitt and March, 1988; Levinthal and March, 1993) and core rigidities (Leonard-Barton, 1992).

Insert Table 2 about here

Secondly weak ties, such as the ties formed during open innovation, are regarded as good at bringing in ideas but they are also seen as problematic for transferring knowledge, and especially tacit knowledge. The theory of weak ties advocates that weak ties (i.e. infrequent and distant relationships) are likely to be more advantageous for finding knowledge because they provide access to novel information by bridging together otherwise disconnected groups and individuals in an organization (Granovetter, 1973; Hargadon and Sutton, 2000). However, knowledge transfer theory suggests that knowledge is sticky or hard to transfer across boundaries (Szulanksi, 1996; von Hippel, 1998). Tie strength, which reflects the closeness of a relationship and increases with frequency of interaction and communication, has been found empirically to lead to greater knowledge transfer (Hansen, 1999, 2002; Tsai, 2002). Strong ties, rather than weak ties, have been shown to be particularly instrumental in sharing tacit knowledge across organizational boundaries (Mowery, Oxley and Silverman, 1996; Dyer and Singh, 1998; Dyer and Nobeoka, 2000).

Thirdly, for complex interconnected organizational routines knowledge transfer theory advocates a "copy exact" approach where a recognized best practice employed is encapsulated in the form of a "working template" (Nelson and Winter, 1982), and then replicated (Jensen and Szulanski, 2004). The template acts as a referent during the copying process but then can be safely adapted once the template has been copied across (Jensen and Szulanski, 2004). This appears to be theoretically problematic for situations when process knowledge is being transferred through weak ties.

Fourthly, a lack of absorptive capacity prevents firms from bringing in external knowledge (Szulanski, 1996). Absorptive capacity refers to the ability to recognize, assimilate and apply new external knowledge (Cohen and Levinthal, 1990).

From an operations perspective bringing in knowledge through intermediary networks creates significant integration challenges that impact absorptive capacity. These challenges are analogous to those experienced with conventional suppliers or with DPD (Parker and Anderson, 2002; Amaral et al, 2011). For instance, who within the firm should be selected to initiate and manage the ongoing relationships with these intermediary networks that link companies to other potential suppliers? How should they be selected? What skills and capabilities should they have and how should they be retained, trained and rewarded? How should they conduct these boundary-spanning roles? Is this role similar to value or supply chain integrators for DPD? (Parker and Anderson, 2002; Amaral et al. 2011). Another integration challenge is how to break down the problems that may be required to pass through the boundary between the company and the intermediary networks and how to decide which problems should be passed to which networks. How should these problems be specified? How should the specifications be communicated in a way that is understood by other cultures and backgrounds? Another challenge is to decide on the nature of the rewards or bounty to be offered to the network and its participants. There is also a challenge to decide how to technically post problems and operate within these networks. Governance structures need to be put in place to reconcile the needs of the functional areas of the project and the people administrating the networks and within the networks themselves. Finally, since the success factors of seeker-solver network integration are not yet well understood, there is the challenge of putting in place learning routines to address integration challenges as they become apparent.

While these theoretical and operational problems exist with open innovation, companies have developed some practical solutions to overcoming these challenges drawn from procurement and design communities. Procurement organizations have developed organizational

learning routines when dealing with outsourcing that can be adapted (Billington and Johnson, 2003; Amaral, Billington and Tsay, 2006). Design communicates have also created routines to deal with codified and un-codified knowledge via whirlwind and gladiatorial design processes (Terwiesch and Ulrich, 2009). This is consistent with research that shows that transfer stickiness can be reduced by developing second-order organizational learning routines adapted for use within different search channels (Brown and Duguid, 2000, Laursen and Salter, 2006).

4. METHODOLOGY

This research is based on a combination of exploratory qualitative case research (Eisenhardt, 1989, Yinn, 2003) with companies using seeker-solver networks to address R&D challenges and five years of action research (Stringer, 1999; Reason and Bradbury, 2001). working with multinationals addressing business process innovation challenges. Our research sample included 16 multinational companies and two NGOs companies from a wide range of different industries and the process challenges included 63 different projects (Table 3). Three of the case studies were transformed into teaching cases (Billington and Jager, 2007; Billington and Barnett Berg, 2008a; Billington and Barnett Berg, 2008b).

Insert Table 3 about here

---

5. FINDINGS ABOUT LEARNING ROUTINES FOR OPEN INNOVATION

Our exploratory research revealed that companies using procurement and design methodologies could develop specific organizational learning routines to effectively bring in

external knowledge using intermediary networks. We found that the routines for bringing in codified and un-codified knowledge, while similar and involving the same essential steps also had important differences. We will now describe the learning routines in some detail (Table 4).

Insert Table 4 about here

---

1. Identify the business problem

In the first step the business problem is identified and characterized by the degree of codified knowledge likely to be contained in a solution. The answers to all problems can be considered as some combination of codified and un-codified knowledge (Figure 4). At one end of the spectrum there are problems where the knowledge seeker believes that a codified answer will be possible. Examples might include a seeker looking for a way to synthesize a specific molecule for a chemical process, or a specific packaging type, or an answer to a mathematical problem. Identifying problems requires a certain organizational culture. For instance, an R&D manager at a large chemical company commented, "You must have a cooperative mindset and then to be open to share your problem - which is quite difficult for a scientist – not a common profile. You need to have a mindset of team work, write problems with other people and for this to be seen as positive." Creating this culture is an internal integration challenge.

In these cases the sourcing challenge is to cost-effectively find as many potential solutions as possible and to evaluate these answers according to a set of codified criteria. Used widely in procurement departments, the procurement process is about sourcing a set of candidate solutions and conducting a set of gladiatorial contests to find the "best" solution.

Insert Figure 4 about here

At the other end of the spectrum there are problems where the solution is likely to be largely un-codified with a high degree of tacit knowledge and systemic interplays. This is the case when dealing with a set of interconnected routines that exhibit a chronic problem. These routines are embedded in human work systems and any solution is highly context-dependent, involving changes to the ways in which employees work, interact and behave. Codified answers appropriate for the context are unlikely to exist as no other organization has the same environment and culture. These problems would have already have been fixed if there was a well known improvement available within the company or the industry through the migration of industry personnel (Almeida and Kogut, 1999). Examples might include improving the procurement to payment process or introducing a new performance management system within an organization. For instance, in one project the Country Managing Director of a large wholesale bank was worried about the competitive situation of her bank. The organization was facing increased competition from international banks offering more innovative products. In addition, the bank was selling predominantly low-margin products to its corporate clients, achieving low returns on capital. The Country Managing Director knew that her bank needed to partner with its corporate clients and use in-depth knowledge of those clients to sell higher margin products. Achieving this required changing the power structure, compensation methods and hiring processes and would likely result in the departure of their most successful sales people. In these cases the challenge is to find knowledge brokers who can constructively stimulate the

construction of new scripts for different part of the routines. This is similar to a firm procuring services but retaining management responsibility.

Intermediate problems contain some elements of knowledge that are likely to be codified and other elements where the amount of tacit knowledge is still significant. For example, one company in the sample from the electrical goods industry was attempting to reduce their finished goods inventory. This problem contains codified elements, for example knowing the correct algorithms for setting safety stock levels, and also un-codified elements, for example, understanding how to set up the human processes of deciding how and when to liquidate excess stock to balance the risk of inventory write down costs with the risk of disappointing customers.

2. Form the appropriate team

In the second step we found that companies need to carefully assign teams with the correct scope of knowledge to work on the problem. For highly codified problems teams should contain team members that have the specialist knowledge to be able to describe the problem in the correct technical terms and to be able recognize a solution when they see it. For example the process of searching for a better manufacturing process to put toothpaste into a tube requires a combination of experts from manufacturing, quality, product development, logistics and marketing. Careful consideration has to be made to team formation because the team collectively needs to be able to judge whether the solution will be viable for every part of the value chain including all the other major suppliers, channel partners, and any other partners. In the previous example the logistics team member needs to be able to represent not only the company point of view but also the point of view of the channel partner.

These teams should also be working with the support of procurement managers that have the specialist knowledge of the outsourcing routines for working through intermediary networks. This is provided that the company has chosen to make sufficient investments to develop this integration capability. Companies must augment their procurement capabilities to include that of seeker-solver integrator.

Un-codified problems involving systemic routines that span across functional and/or organizational boundaries usually requires a much more diverse team. It is important to bring together people that can see all the different aspects of the overall business system (a combination of value chains working together to deliver the product or service) and who have knowledge of the interconnections within the business system. For example, the Finance Director of a large global company was concerned that his function was behaving reactively rather than proactively. Managers were spending too much time working on reporting basic financial information rather than spending time advising their internal clients on how to build their business and how to run their business more profitably. The global team, which was drawn from throughout the company, was charged with i) installing a process of continuous improvement within financial reporting, starting with the mid-term reporting process, ii) teaching finance managers to be more customer oriented and better communicators, iii) creating a more robust HR function to address the specific needs of the finance function. This global team was composed of individuals from every geography and every line of business with the financial services group i.e. private banking, wholesale banking, retail banking, insurance, online direct banking, real estate, management reporting, legal reporting, company financial reporting, controllerships and risk function. Drawing team members widely ensures that the politics, resources and interfaces to the wider business system are adequately represented during the project.

3. Disaggregate the problem into smaller elements

Disaggregating the problem requires the team to break the challenge down into pieces determined by who can solve the various parts of the problem, and how these parts will be addressed using open innovation networks. Similar to an outsourcing RFP, to be able to source ideas externally the problem needs to be broken into the right-sized pieces. If it is too big then you won't find solvers or brokers who already possess an answer. If it is too small then you are unlikely to get anything of value from external sources. You want to construct the problem so that you get a few valuable answers rather than 100s of uninteresting answers (Terwiesch and Xu, 2008).

With highly codified problems the starting point is to understand how to leverage the relative strengths of internal and external knowledge. Some elements of the problem, especially those most routine to the organization, may still be best addressed by the corporate lab or through alliances with regular suppliers or universities. Other elements of the problem may be well-suited to sourcing through intermediary open innovation networks. Companies should use the same process to take this decision as they would with any outsourcing decision i.e. considerations of risk adjusted cost-benefits. Cost considerations need to include the projected costs of resolving parts of the problem including transaction costs. Risk that should be taken into account includes the risk of undesirable knowledge spillovers to competitors (Dyer and Nobeoka, 2000). Even though the challenges on most formal intermediary networks are posted anonymously, some managers are afraid that industry insiders can deduce which challenges are theirs, thus signaling the competition about their actual R&D objectives. This issue can be addressed by "thinly slicing" challenges; that is constructing them in such a way that they do not disclose the strategy

or commercial intent behind the challenge. As an example, when solvers work on a P&G challenge on the InnoCentive platform, it is clear which molecule P&G wants to synthesize but the use of the molecule, the way it would be manufactured, and which product would use the molecule is left to suppliers and the internal P&G R&D lab, minimizing competitive signaling. This problem is routinely addressed by intermediary networks.

Another integration challenge is how to properly frame the challenge for solvers, using the right terms and offering the right incentives. The problem needs to be condensed down to a level at which the seeker rationally believes that there is available expertise, understanding, and capability in the "outside" world. One InnoCentive user, a major pharmaceutical company, gives a glimpse of the typical approach to developing these capabilities. "The approach was pretty ad hoc at first, but we learned quickly that we needed to put some structure around it and help drive it", said the company's vice president on R&D. "You don't want to put all your recalcitrant challenges out there, because that doesn't offer the greatest opportunity, and not all problems fit InnoCentive."

For un-codified problems the first step is to explore the problem and gain insights into the systemic behavior of the system. The seeker team needs to spend time evaluating the strengths and weakness of the integrated routines and identifying any repeating patterns or systems archetypes that are causing repeated failure e.g. tragedy of the common, addiction models etc (Kim, 2000). In some cases processes may be missing entirely or parts of the governance process may be weak. For instance, the General Manager of a European market in the beverage industry was facing tough competition. The market was split three ways with the three players holding equal market shares. The company had not made a profit in several years and regional management was dissatisfied with the organization's performance. In this problem the dynamics

of competition when there are three equal players is well known as creating a systemic problem for overall industry profitability.

Breaking down the problem into smaller pieces is essential because the highly contextual nature of these problems means that the company is unlikely to find an answer out in the world that encapsulates the same set of integrated routines. For example, a large fast-moving consumer goods company accustomed to operating in grocery stores wanted to increase its competitiveness in specialist channels. By looking more closely at the problem of how to increase sales volumes and profitability in the new channels team members identified four discrete elements, each suggesting a different challenge requiring specific expertise (Figure 5). In the cases that we looked at there were no ironclad rules for breaking apart the business problem other than to find points of leverage where tacit knowledge from outside the industry could prove useful. But the problems have to be small enough that the team can adequately address the political context, the company resource use and distribution, and the most important interfaces with business system partners.

Insert Figure 5 about here

We found that it is easier for teams to have insights into these points of leverage if the information about the company, industry, or product contexts is removed from the problem statement. For instance, a team from a European retail bank wanted to improve customer queuing in their branches. A vital first step was for the team members to ask themselves the question, “In which other industries is queuing and the management of service delivery resources a vital

competence." This enabled them to identify industries such as amusement parks, supermarkets, highway traffic resource planning systems, and media stores with high seasonal customer level variation as potential sources of ideas.

4. Find solvers or knowledge brokers

For codified problems finding the appropriate intermediary networks seems to involve some amount of trial and error. It is about reaching an understanding of which networks appear to be more productive for which sort of problems. To maximize value it is important to work with multiple networks and to develop your internal work processes for interfacing with these networks. Another integration challenge is to create a standardized process to determine the size of the reward or bounty. The process for breaking up the problem into smaller pieces may be dependent on the types of networks that are being used. For instance, a firm desiring to cut its energy use may write their challenge very differently to seek energy cost improvement ideas from a network such as Skipso, who brokers alternative energy ideas, versus writing a challenge to Innocentive, which might centre around how to redesign product characteristics to consume less energy.

For un-codified problems it is less about breadth of search and more about finding knowledge brokers that have a deeper experience than the seeker of the different parts of the overall problem. This creates knowledge brokering potential (Figure 6). For example, a fast moving consumer goods company needed to protect their industry business systems from new entrants and government regulation. This company had a highly immature IP management process for valuable patents that could be used to reinforce their supply chain. The lack of maturity of the IP management process created the potential for bringing in knowledge from high

tech firms. As the vice-president of mergers and acquisitions told us, "We realized that we were very limited in our view of IP management and that surprisingly other industries could add a lot of knowledge to our current ways of working that we could adapt to our context."

Insert Figure 6 about here

---

5. Incorporate knowledge into organizational context

Within the innovation process there are 2 different ways of incorporating potential answers from the external search; gladiatorial and whirlwind processes. In a gladiatorial process where the solution can be codified, the company is looking for the best solution to the problem. There are two elements that increase the probability of a superior outcome; the number of potential solutions and the diversity of those solutions. Potential solutions supplied from the networks need to be screened or filtered (Terwiesch and Ulrich, 2009). The experts on the team need to carefully construct the filter to identify the best solution. This is similar to a sourcing event where a better result comes from examining more suppliers with objective criteria. For instance, when e.on UK was designing a responsible procurement program, one task was to create a supplier assessment survey, they collected five different company assessments and in two hours they were able to create their own survey by picking and choosing the most relevant parts of each and adding their own ideas to take into account their own unique context. The supply chain director commented on the resulting award winning responsible procurement program, "We entered the program in a confused state and left, in a very short space of time with a plan. Benefits were learning and understanding the power of knowledge brokering….The

volume of output generated in this intense week was totally staggering…a feat that, if done while trying to do our daily jobs, would have taken years!" (Billington and Barnett Berg, 2008a). In this case gladiatorial contests rapidly found codified answer to specific parts of the problem.

In a whirlwind innovation process where the solution is largely un-codified, the team is looking for solutions that are substantially better than the current interconnected routines. There is no right answer but if the team can create three or four major improvements then the overall process is likely to be substantially better. Using this process the team takes ideas from tacit knowledge gleaned from other industries and puts these ideas together in novel ways, supplemented with ideas from people in the team. Important parts of this process are brainstorming and rapid prototyping, typically used by product designers. Multiple perspectives from team members drawn from different functions provide different lenses on what is and is not possible when combining ideas. In contrast with gladiatorial contests where there is a best solution, the team needs to use collective intelligence of the team members and deep organizational knowledge to assess the feasibility of these newly constructed organizational routines. For instance, using the same example as above, e.on UK, divided their problem into a a topology of eight sub-problems; performance standards, risk assessment methodology and process, supplier survey, audit process and goals, reporting process and KPIs, roles and responsibilities, change management process, communication plan. Each of these sub-problems used a gladiatorial knowledge brokering process to create candidate solutions. These solutions were then combined using a whirlwind design process to produce a prototype of the total design that can be integrated into the existing organizational procurement processes. The resulting prototype is then ready for pilot testing.

6. Pilot

The final step of embedding an innovation into an organization is to pilot the prototype. In the case of highly codified answers this is about checking that the solution works and produces the desired effect in the system where it is used. If not, then the team needs to go back to the intermediary networks to refine the search and look for other possible answers. Sometimes it may be better to purchase several of the more attractive solutions. It is an open research question how many to buy and under what context. Another approach is to take a small subset of suppliers who came close to finding acceptable answers and to ask them to compete again using the refined brief and a different bounty (see also Terwiesch and Xu, 2008).

In the case of un-codified answers it is about taking the prototype and then "learning by doing". For a new organizational practice piloting takes place through a series of integrator-led iterative pilots where the new process becomes refined over time (Billington and Barnett Berg, 2008b). Pilots of new processes need to be credible, replicable, and feasible in order to create new frames that generate affective commitment and adoption of the new ways of working (Davidson and Büchel, 2011). For instance, in the e.on case the new responsible procurement process was perfected in the UK before rollout into European markets. In an exploratory setting, the integrator pilots through a series of multi-sample experiments to test different designs and see which design works best.

A key part of working in this way is that some part of the organization is formally accountable for institutionalizing these methods. The challenges associated with spanning the organizational boundary to these networks require creating human seeker-solver network

integrators. For many organizations this role is completely new and is challenging to hire, train and retain.

6. CONCLUSION

The nature of supply chains is changing. The rise of the Internet accompanied by the drastic reductions in the cost of communication and increasing degrees of connectivity is allowing firms to solve problems differently. It is now becoming faster and cheaper to source knowledge from solvers or knowledge brokers who have answers rather than to create knowledge internally or through traditional supplier networks. The three supply chain flows of goods, money and information (Lee and Billington 1992) are now being supplemented by a fourth flow of ideas from unconventional suppliers outside of the traditional supplier base.

Companies can now source both codified and un-codified knowledge using open innovation techniques. It is possible to do this because of the creation of suitable network infrastructure (intermediary networks) coupled with the development of appropriate organizational routines. CEOs and senior managers need to recognize that procurement and design processes lie at the root of these routines. This second-order capability will be strategically vital for companies going forward because of the competitive advantage offered by this new form of knowledge sourcing.

There are rich opportunities for further research in this area, where success factors are still not widely understood. Some topics might include the analytical methods for deconstructing problems and forming the problem topology; correctly setting the size of the bounty; how to decide whether a problem should remain internal, go to the traditional supply base or to seeker-solver networks; how many codified solutions to buy; how much knowledge brokering to con-

duct and finding the right brokers; how to manage the human capital aspects of the seeker-solver integrator; how to create a governance structure for these processes; and other questions.

REFERENCES

Almeida, P., Kogut, B. (1999). Localization of knowledge and the mobility of engineers in regional networks. *Management Science,* 45(7), 905-917.

Amaral, J., E.G. Anderson JR, G.G. Parker (2011). Putting it together: How to succeed in distributed product development. *Sloan Management Review,* Winter, 52(2).

Amaral, J., C.A. Billington, A.A. Tsay (2006). Safeguarding the promise of production outsourcing. *Interfaces,* 36(3), 220-233.

Billington, C., M. Barnett Berg. Chasing the Zeitgeist: Making change at the heart of an amorphous organization. IMD-3-1951, Lausanne: IMD, 2008.

Billington, C., M. Barnett Berg. Activist inside: Making responsible procurement happen . IMD-3-1952, Lausanne: IMD, 2008.

Billington C., R. Davidson (2010). Using knowledge brokering to improve business processes. *McKinsey Quarterly,* January.

Billington, C., F. Jager. La Cuisine Francaise: The InnoCentive experience. IMD-6-0295, Lausanne : IMD, 2007.

Billington, C., F. Jager. (2008). Procurement: The missing link in innovation. *Supply Chain Management Review,* Jan-Feb, 2008.

Billington, C., B. Johnson (2003). Creating and leveraging options in high technology supply chain. In the Practice and Supply Chain Management: theory and application converge. Eds. T. Harrison, H. Lee and J. Neale, Kluwar Academic Publishing, 157-174.

Brown, S.L., P. Duguid (2000). The social life of information. Harvard Business School Press. Boston, MA.

Brown, S.L., K.M. Eisenhardt (1995). Product development: Past research, present findings and

future directions. *Academy of Management Review*, 20(2), 343-378.

Cassiman, B., R. Veugelers (2006). In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. *Management Science*, 52(1): 68-82.

Chan Kim, W., R.A. Mauborgne (1993). Procedural justice, attitudes and subsidiary top management compliance with multinationals' corporate strategic decisions. *Academy of Management Journal*, 26(3), 502-526.

Chesborough, H. (2003). The era of open innovation. *Sloan Management Review*, Summer 35-41.

Chesborough, H. (2005). Open innovation: The new imperative for creating and profiting from technology. Harvard University Press, Boston.

Chesborough, H. (2007). The market for innovation: Implications for corporate strategy. *California Management Review*, 49(3): 45-66.

Cohen, W.M., D.A. Levinthal (1990). Absorptive capacity: a new perspective of learning and innovation. *Administrative Science Quarterly*, 35, 128-152.

Davidson, R., B. Büchel (2011). The art of piloting global strategic process initiatives, *Sloan Management Review*, 53(1), 79-86.

Dyer, J.H., K. Nobeoka (2000). Creating and management a high-performance knowledge-sharing network: The Toyota case. *Strategic Management Review*, 21, 345-367.

Dyer, J.H., H. Singh (1998). The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *Sloan Management Review*, 35(1), 51-6.

Eisenhardt, K.M. (1989). Building theories from case study research. *Academy of Management Review*, 532-50.

Gerson Lehrman Group corporate website (2010) available from http://www.glgroup.com/

Granovetter, M.S. (1973). The strength of weak ties. *American Journal of Sociology*, 6, 1360-1380.

Hansen, M.T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly,* 44, 82-111.

Hargadon, A., R. Sutton (2000). Harvard Business Review 78(3), 157-166.

Jensen, R., G. Szulanski (2004). Stickiness and the adaptation of organizational practices in cross-border knowledge transfers. *Journal of International Business Studies,* 35(6), 508-523.

Katila, R., G. Ahuja, (2002). Something old, something new: a longitudinal study of search behavior and new product introduction. *Academy of Management Journal,* 45, 995-1010.

Katz, R., T. Allen (1982). Investigating the not invented here (NIH) syndrome: a look at the performance, tenure, and communication patterns of 50 R&D projects. *R&D Management,* 12 (19), 7-19.

Kogut, B., U, Zander (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science,* 3(3), 383-397.

Kraatz, M. S. (1998). Learning by association? Interorganizational networks and adaptation to environmental change. *Academy of Management Journal*, 41(6): 621-643.

Lakhani, K.R., L.B. Jeppeson, P.A. Lohse, J.A. Panetta (2006). The value of openness in scientific problem solving. Harvard Business School Working paper No07-050.

Laursen, K., A. Salter (2006). Open innovation: The role of openness in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal*, 27, 131-150.

Lee, H. L., C. Billington. Managing Supply Chain Inventory: Pitfalls and Opportunities, *Sloan*

Management Review, 33(3), 65-73.

Leonard-Barton, D. (1992). Core capabilities and core rigidities: a paradox in managing new product development. *Strategic Management Journal,* Summer Special Issue, 13, 111-126.

Levinson, N.S., M.Asahi (1996). Cross-national alliances and interorganizational learning. *Organizational Dynamics,* 24, 51-63.

Levitt, B., J.G. March (1988). Organizational leaning. In W. Richard Scott and Judith Blake (eds.). *Annual Review of Sociology,* 14, 319-340. Palo Alto, CA: Annual Reviews.

Levinthal, D.A., March, J.G. (1993). The myopia of learning. *Strategic Management Journal,* Winter Special Issue 14, 95-112.

March, J.G., H. Simon (1958). Organizations. Wiley, New York.

Mowery, D.C., J. E. Oxley, B. S. Silverman (1996). Strategic alliance and interfirm knowledge transfer. *Strategic Management Journal,* 17 Winter Special Issues, 77-91.

Nelson, R., S. Winter (1992). An evolutionary theory of economic change. Belnap Press: Cambridge, MA.

Nonaka, T. (1994). A dynamic theory of organizational knowledge. *Organization Science*, 5, 14-37.

Parker, G.P., E.G. Anderson JR (2002). From buyer to integrator: The transformation of the supply chain manager in the vertically disintegrating firm. *Productions and Operations Management,* 11(1): 75-91.

Powell, W.W., K.W. Kogut, L. Smith-Doerr (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology, *Administrative Science Quarterly,* 41, 116-145.

Reason, P., H. Bradbury. (2001). Handbook of action research: Participative inquiry and practice: Sage Publications Ltd.

Rosenberg, N. (1982). Inside the black box: Technology and economics. Cambridge University Press, Cambridge, UK.

Rosenkopf, L., A. Nerkar (2001). Beyond locla search : Boundary-spanning exploration, and impact in the optical disc market. *Strategy Management Journal,* 22, 287-306.

Rayner, M.E., J.A. Panetta (2005). A better way to R&D? *Strategy & Innovation,* 3(2), March-April.

Sakkab, N.Y. (2002). Connect and develop complements research and develop at P&G. *Research Technology Management,* 45(2), 38-45.

Scott, C., J.S. Brown (1999). Bridging epistemologies: the generative dance between organizational knowledge and organizational knowing. *Organization Science,* 10(4), 381-400.

Sommer, S.C., C. Loch (2004). Selectionism and learning in projects with complexity and unforeseeable uncertainty. *Management Science,* 50(10): 1334-1347.

Stringer, E.T. (1999). Action Research. 2nd edition. Thousand Oaks, CA: Sage.

Szulanksi, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal,* Winter Special Issue, 17, p27-43.

Tapscott, D. (2006). Wikinomics: How mass collaboration changes everything. Portfolio Hardcover, Dec 28.

Terwiesch, C., K. Ulrich (2009). Innovation Tournaments: Creating and selecting exceptional opportunities. Harvard Business School Press, Boston.

Terwiesch, C., Y. Xu (2008). Innovation contests, open innovation, and mulitagent problem

solving. Management Science, 54(9) : 1529-1543.

Tidd, J., J. Bessant, K.L.R. Pavitt (2000). Managing innovation: Integrating technological market and organizational change (2nd edition), Wiley, Chichester.

Tsai, W. (2002). Social structure of "coopetetion" within a multiunit organization: Coordination, competition, and intraorganizational knowledge sharing. *Organization Science,* 13(2), 179-190.

von Hippel, E. (1988). Sources of Innovation Oxford University Press, New York.

Yin R. (2003). Case study research: Design and methods (3rd ed.). Thousand Oaks, CA: Sage.

Zander, U., B. Kogut (1995). Knowledge and the speed of transfer and imitation of organizational capabilities: An empirical test. *Organization Science,* 6, 76-92.

Figure 1: Characteristics of intermediary networks

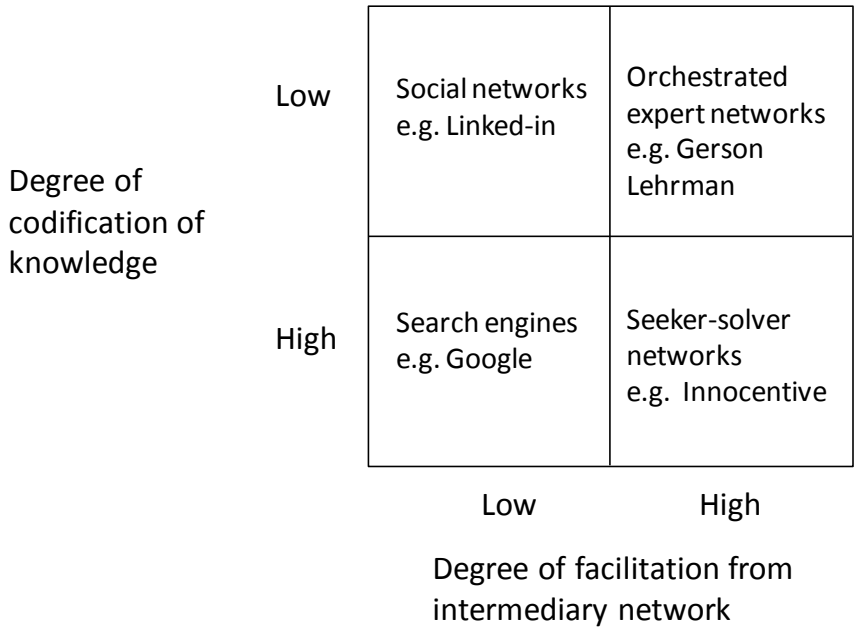


Figure 2: Larger networks mean higher returns on innovation investment

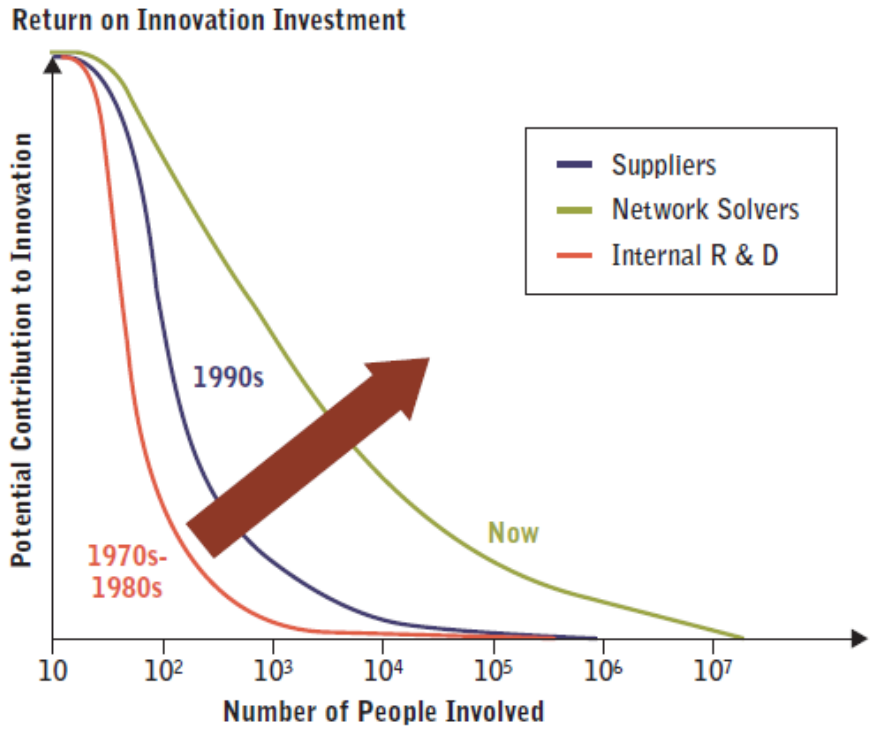


Figure 3: Innovation before and after intermediary networks

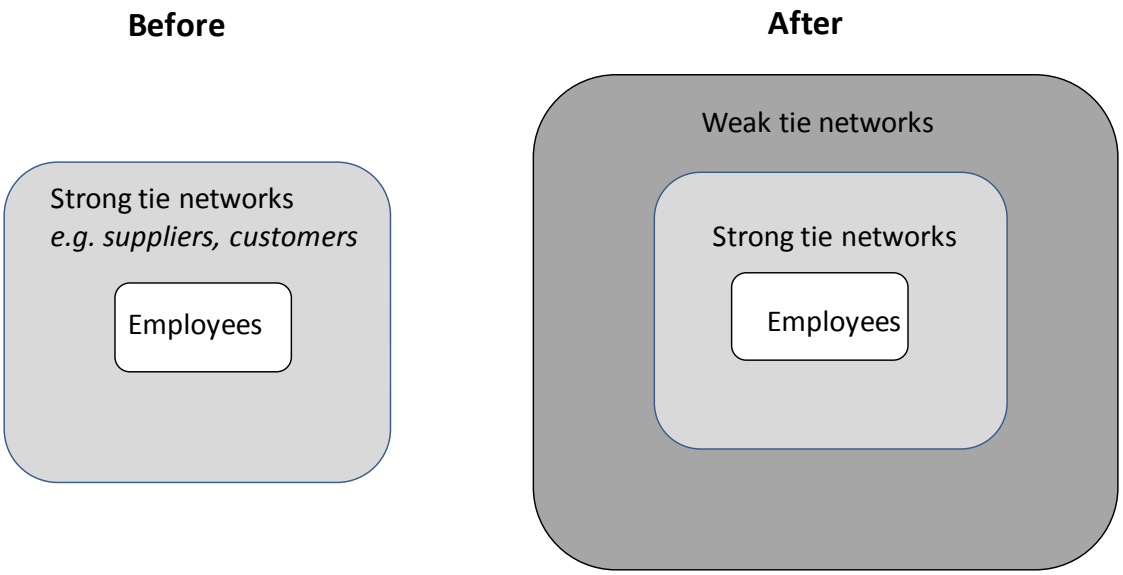


Figure 4: Problems display a range in degree of codification of the answers

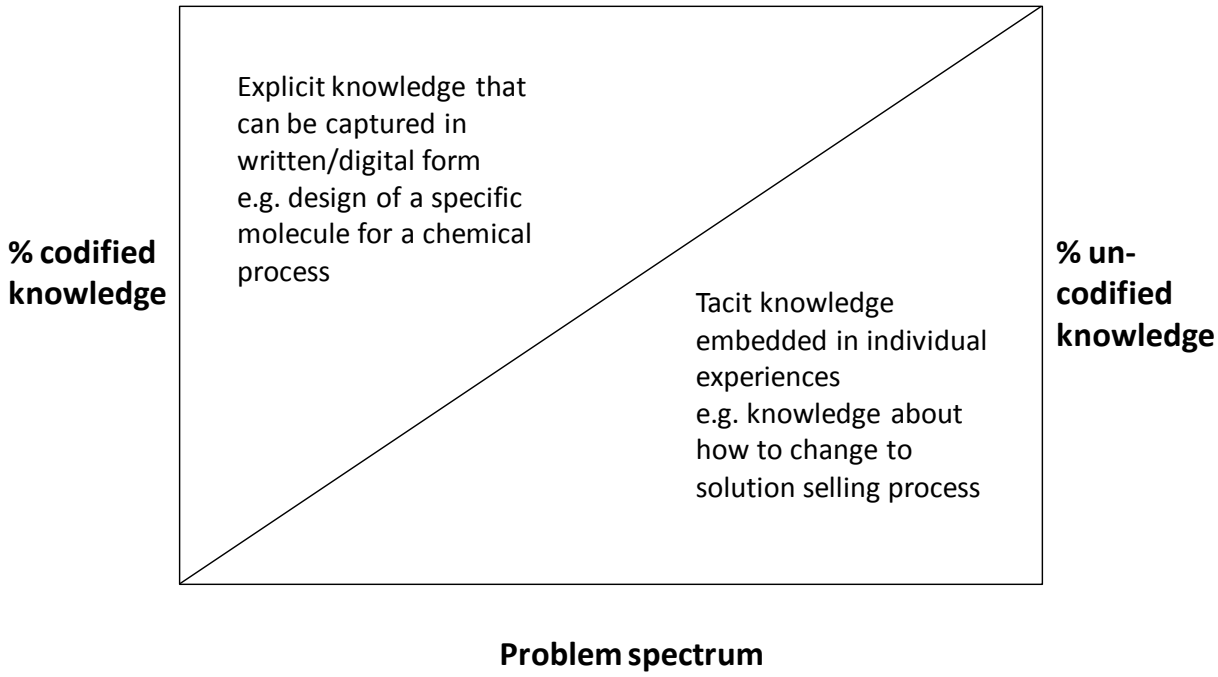


Figure 5: High level problem for a large, fast-moving consumer goods company: Increase the sales volumes and profitability within specialist channels

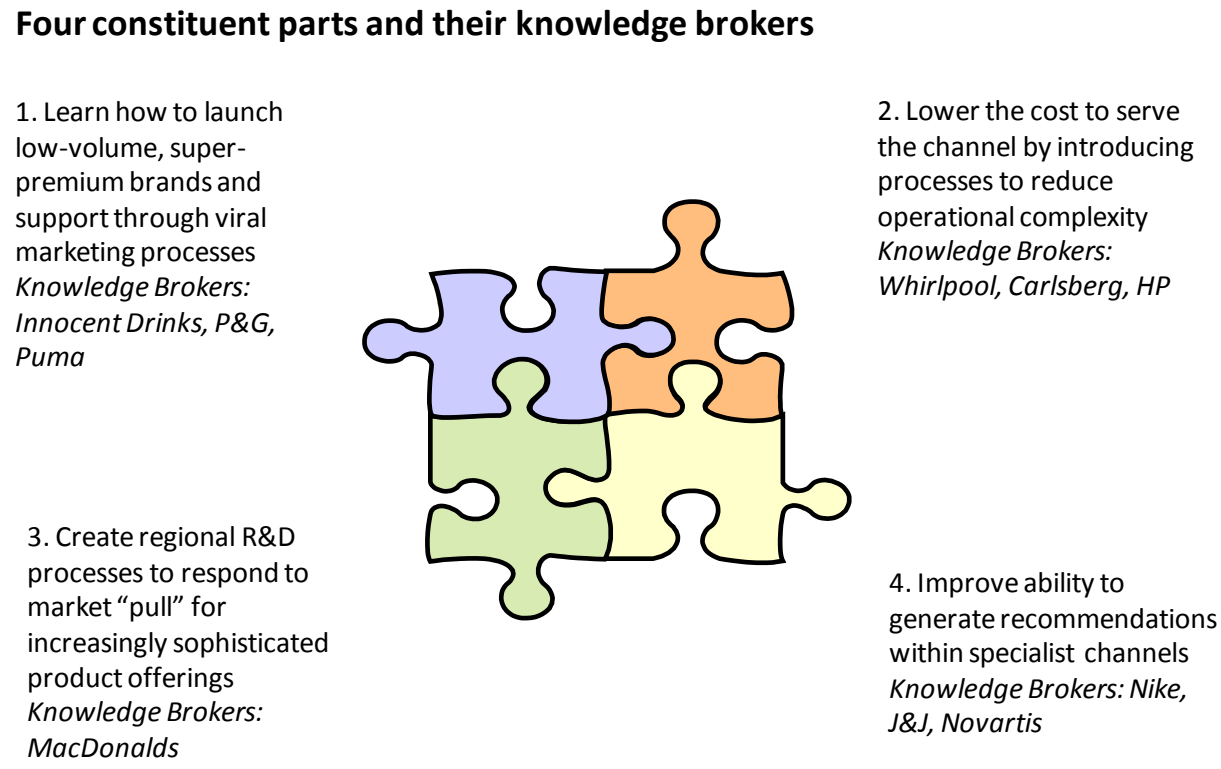
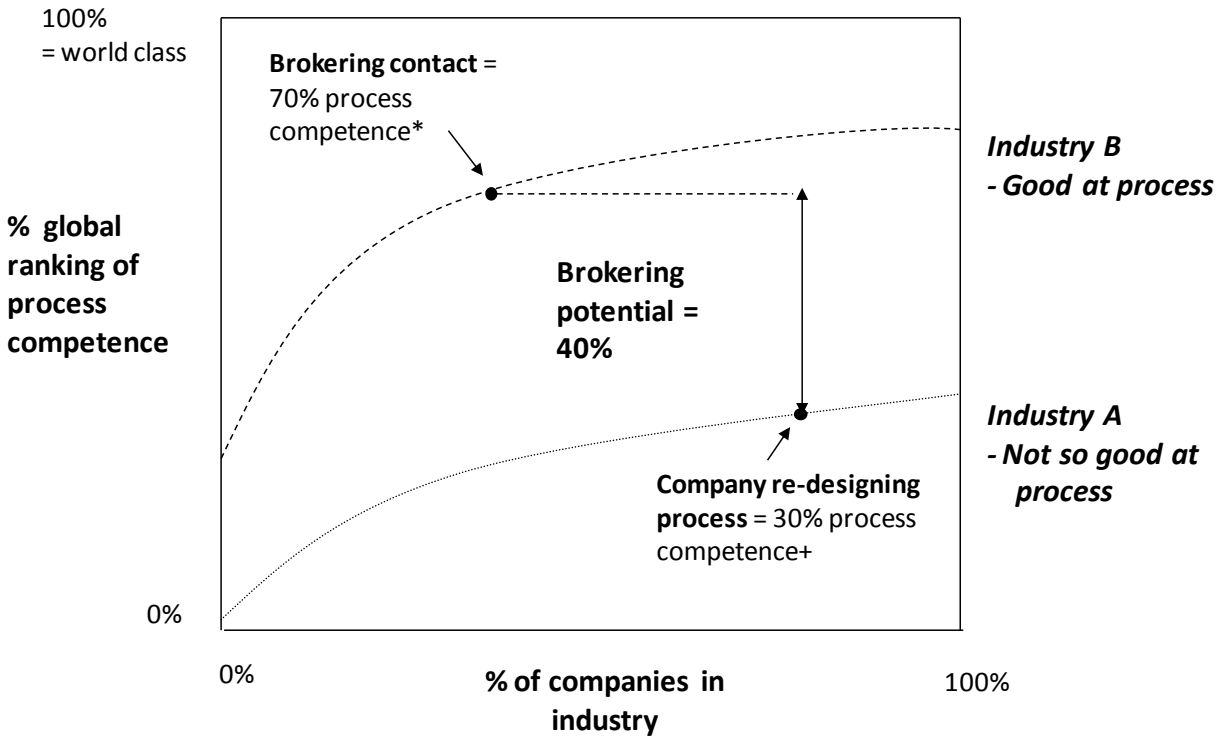


Figure 6: Finding knowledge brokers relies on finding industries where companies are measurably better at similar processes



* This company is not a leader in this process within their industry, but are much better than any company within industry A

+ This company is among the leaders in this process in their Industry

Table 1: Facilitated intermediary network platform examples

R&D, Science and Technology

Network	Network Business Focus	Challenge Types
Innocentive	R&D, Science, Pharmacology	Theoretical, Brainstorming and Reduction to practice challenges
Idea Connection	R&D, Supplier sourcing,	Innovation challenges Invention marketplace
NineSigma	Innovation management Sustainability Intermediary services	Innovation challenges
One Billion Minds	Technology, design, science and social problems Brainstorming, Idea Exchange	Project challenges
Yet2	R&D, Science	IP marketplace IP challenges to find applications
Presans	R&D	R&D challenges, IP marketplace IP brainstorming
Innoget	Science, Engineering, Technology	Innovation challenges, IP market

Marketing, Sales and Prediction

Innovaro	Market prediction and Foresight, IP marketplace Brainstorming	Project challenges
Ideaken	Marketing, sales campaign	Marketing challenges
Innovation Exchange	Marketing, Design, Sustainability	Project challenges Innovation marketplace
RedesignMe	Logos, Marketing, Design	Innovation challenges
Kaggle	Data mining Forecasting	Data contest projects
NewsFutures	Innovation mashup	Prediction markets
Intrade	Global prediction markets	Prediction markets

Sustainability

Brainrack	Education, Sustainability	Student challenges, Brainstorming
MyooCreate	Environmental, Social problems	Project challenges
Skipso	Environmental, Sustainability	Project challenges, Grants

General Management and Employment

Idea Crossing	Business models, Products, Services, Strategy	Student challenges
Spigit	Innovation management	Innovation challenges using organizational network
LeadVine	Sales leads, Jobs	Sales lead network
ChumBonus	Jobs	Employment challenges
Big Idea Group	Innovation management	Innovation challenges using customers and solvers
Gerson-Lehrman	Specialized functional and industry expertise	Facilitated meetings, panel discussions

Table 2: Theoretical problems posed by open innovation

Theoretical problems	References
1. Not-invented-here-syndrome and local search issues	Nelson & Winter, 1982; Levitt & March , 1988, Katz & Allen, 1982
2. Tacit knowledge is sticky and hard to transfer using weak ties	Szulanksi, 1996; von Hippel, 1998; Hansen, 1999; Tsai, 2002
3. Templates of interconnected routines require a "copy exact" approach	Nelson & Winter, 1982; Jensen & Szulanski, 2004
4. Limited absorptive capacity within firms	Szulanski, 1996; Cohen & Levinthal, 1990;
5. Knowledge work integration challenges	Amaral et al., 2011; Anderson & Parker, 2002 ; Parker & Anderson, 2002

Table 3: Research sample by open innovation challenge

Industry	General strategy challenges	Go to market challenges	Global functional challenges	Operational challenges	Supply chain challenges	R&D challenges	CSR challenges
Banking & financial services	3	5	2	4	0	1	0
Consumer goods	6	8	1	3	2	4	0
Utilities/ industry	6	1	3	0	3	1	1
Professional services	2	1	1	1	0	1	1
Health	1	0	0	0	0	1	0
NGOs	0	0	0	0	0	1	3
Total no of projects	18	15	7	8	5	5	5
No of individuals	218	115	49	58	49	35	43

Table 4: Process for using intermediary networks for open innovation

No	Process step	Codified knowledge	Un-codified knowledge
1	Identify the business problem	Difficult problems where "someone" outside the organization may have solved a similar problem before	Set of interconnected routines or business processes exhibiting a chronic problem
2	Form the appropriate team	Specialist team working with the support of procurement	Team members drawn from all functions involved in the interconnected routines
3	Disaggregate the problem into smaller elements	Focus is on breaking down problem to leverage relative strengths of in-house versus open innovation and to ensure IP protection	Focus is on breaking into sub-routines and creating context-free problem statements to identify other contexts with relevant knowledge
4	Find solvers or knowledge brokers	Select from appropriate intermediary networks and broadcast challenge as widely as possible to find potential solvers	Use intermediary networks to locate executives or professionals with relevant experiences in different industries
5	Incorporate knowledge into local context	Gladiatorial combats to select feasible solutions	Whirlwind innovation process to construct new routines by combining ideas in a novel way
6	Pilot	Verify solution using laboratory tests, pilot plants, or alpha tests before scaling up	Pilot new routines and "learn by doing" followed by rollout
Ongoing	Document and track open innovation performance using KPIs	Knowledge / cost of ideas Interest level of potential solvers No of ideas No of ideas/ intermediary network Success rate ROI	Speed of design of business process (relative to typical speed) Cost of project (relative to typical cost) Degree of implementation and adoption of new routines Degree of satisfaction with new routines